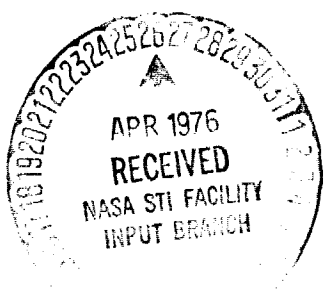
MCR-76-3

Volume V

Cost Analysis

March 1976

Space Tug Docking Study



MARTIN MARIETTA

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Data Requirement No. MA-03

Volume V

Cost
Analysis

March 1976

SPACE TUG
DOCKING STUDY

Approved By

G. J. Dickman
Program Manager

MARTIN MARIETTA CORPORATION
P. O. Box 179
Denver, Colorado 80201

FOREWORD

This study was performed under Contract NAS8-31542 for the George C. Marshall Space Flight Center of the National Aeronautics and Space Administration under the direction of Mr. James I. Newcomb and Mr. Paul T. Craighead, the Contracting Officer's Representatives. The final report consists of five volumes:

Volume I - Executive Summary
Volume II - Study of Results
Volume III - Procedures and Plans
Volume IV - Supporting Analyses
Volume V - Cost Analysis

The study results were developed during the period from June 1975 to January 1976. Principal Martin Marietta contributors to the study were:

Glen Dickman	Study Manager
G. Dickman	Task A Leader, Requirements and Data Base Development
B. King	System Requirements and Operations Analyses
R. Zermuehlen	Subsystem Requirements
R. Schappell	Video Sensors
W. Koppl	Ranging Sensors
C. Park	Docking Dynamics Analysis
B. Dickman	Docking Simulation Program
F. Vandenberg	Rendezvous Simulation Program
M. Crissey, J. Hays, C. Lord	Docking Mechanics
R. Chamberlain	Payload Requirements
R. Zermuehlen	Task B Leader, Candidate System Definition
B. King	Task C Leader, Simulation Demonstration Test Program Definition
E. Cody	Task D Leader, Programmatics Definition

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I. INTRODUCTION

This volume documents and summarizes the cost analysis task of the Space Tug Docking Study. It includes a discussion of the cost methodology, summary cost data, resulting cost estimates by Work Breakdown Structure (WBS), technical characteristics data, program funding schedules and the WBS used for the costing together with a dictionary.

Cost estimates for two tasks of the study are reported in this volume. The first, Task A, developed cost estimates for design, development, test and evaluation (DDT&E) and theoretical first unit (TFU) at the component level (Level 7) for all items reported in the data base. Task B developed total subsystem DDT&E costs and funding schedules for the three candidate Rendezvous and Docking Systems: manual, autonomous and hybrid. A third, Task C, cost estimates to conduct numerous simulation/demonstration tests is included in Volume III.

II. COST APPROACH, METHODOLOGY AND RATIONALE

2.1 Introduction

In accordance with normal Phase A study practice, cost estimates of the Rendezvous and Docking components and subsystems were generated using cost estimating relationships (CERs), cost factors, vendor data, or point estimates. Such a technique provides credible and realistic costs with a confidence commensurate with the level of definition available in the study.

The initial step is the calculation of component DDT&E and theoretical first unit (TFU) costs based on design data such as size and performance definitions. These were derived from CERs, vendor data or ,for components which are not significantly parametric or for which detailed data is not available, an engineering point estimate is used. Each CER relates cost to a specific driving variable (generally weight or performance parameter) that exerts a major influence on cost. These CERs are based, wherever possible, on our actual cost experience, historical cost data from other programs or current cost information from subcontractors or vendors.

These component DDT&E costs are combined with estimated costs for a prime contractor to perform the required integration, analyses and software tasks to generate total DDT&E costs at the subsystem level. The cost factor to derive the integration and analyses cost is developed from our historical experience or other study data.

2.2 Ground Rules and Assumptions

The general ground rules and assumptions used in this analysis are:

- All costs are in 1975 dollars, without contractor fee.
- Three years for subsystem development.
- DDT&E costs include the following cost elements:
  - Design and Development
  - Tooling
  - One (1) development test unit
  - One (1) qualification test unit
  - Two (2) system level test units
  - Testing

- Some components costed with 1977-78 technology.
- Video sensor and RF radar costs are based on minimal change to Shuttle Orbiter hardware.
- Cost to incorporate image data processing capability into the video sensor has not been scoped.

2.3 Work Breakdown Structure (WBS)

A work breakdown structure (WBS) was generated early in the study to identify the major hardware and key elements involved with the Space Tug Project. The WBS is a product-oriented display of both hardware and supporting elements that define the end product to be developed and serves as a common framework for structuring the cost estimates. This preliminary WBS has been updated in light of the study results and a finalized version is presented in Figure II-1.

2.4 WBS Identification Number Sequence

Figure II-2 lists the WB identification number sequence. This numbering sequence consists of eleven digits, which identify the hardware WBS elements to Level 7 (component).

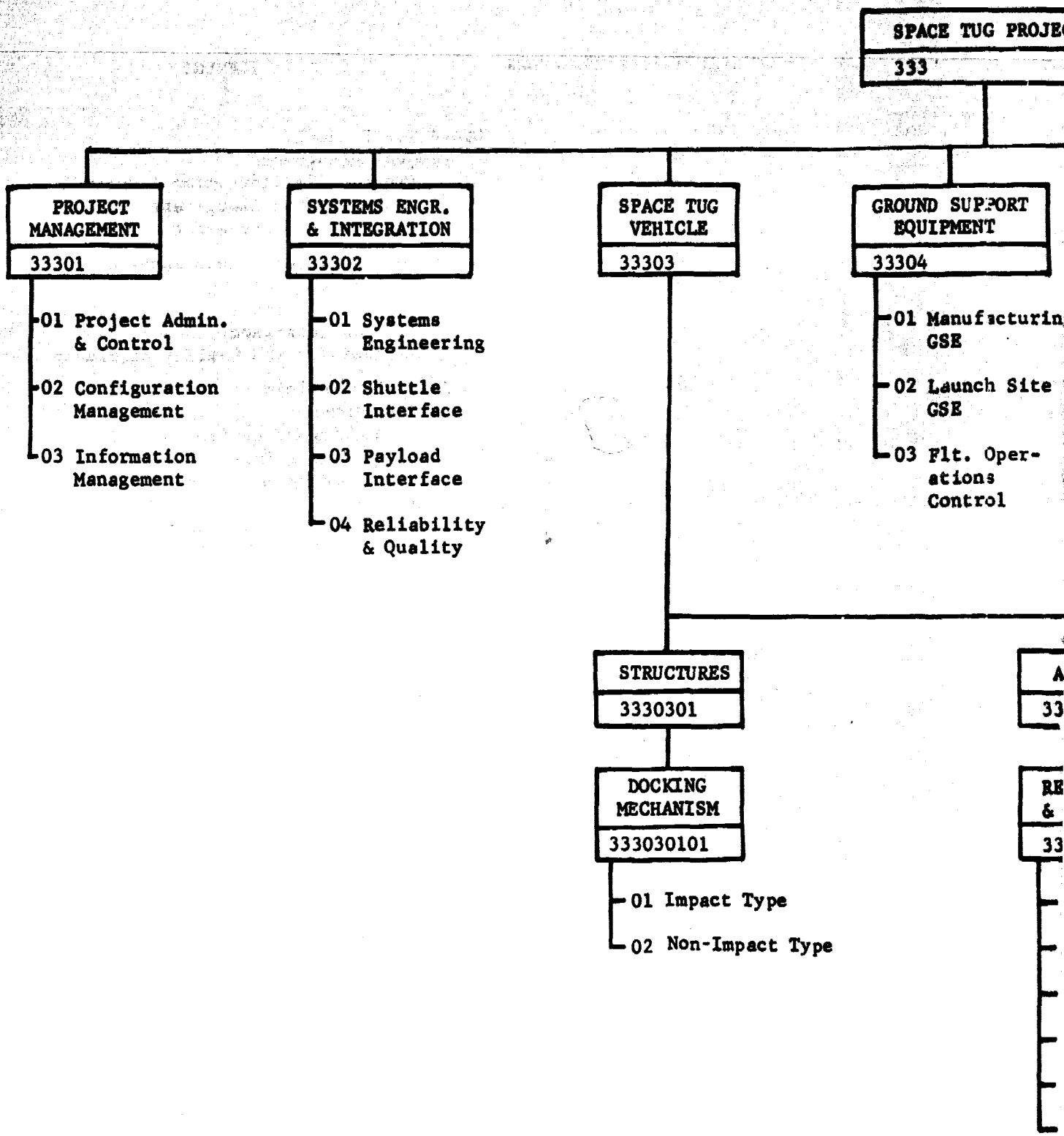
2.5 WBS Dictionary

333 SPACE TUG PROJECT

This element summarizes the direct and indirect (G&A and burden) effort to design, develop, test and evaluate the Space Tug vehicle. It includes all vehicle hardware, software, services, facilities, support equipment, training, data, etc., directly and/or indirectly associated with the Space Tug vehicle.

333-01 PROJECT MANAGEMENT

This element summarizes the management and technical support activities required to administer the overall Space Tug Project. It includes resources budgeting and performance analysis, configuration control of hardware and software, control and maintain status of internal and deliverable project documentation and data.



FOLDOUT FRAME

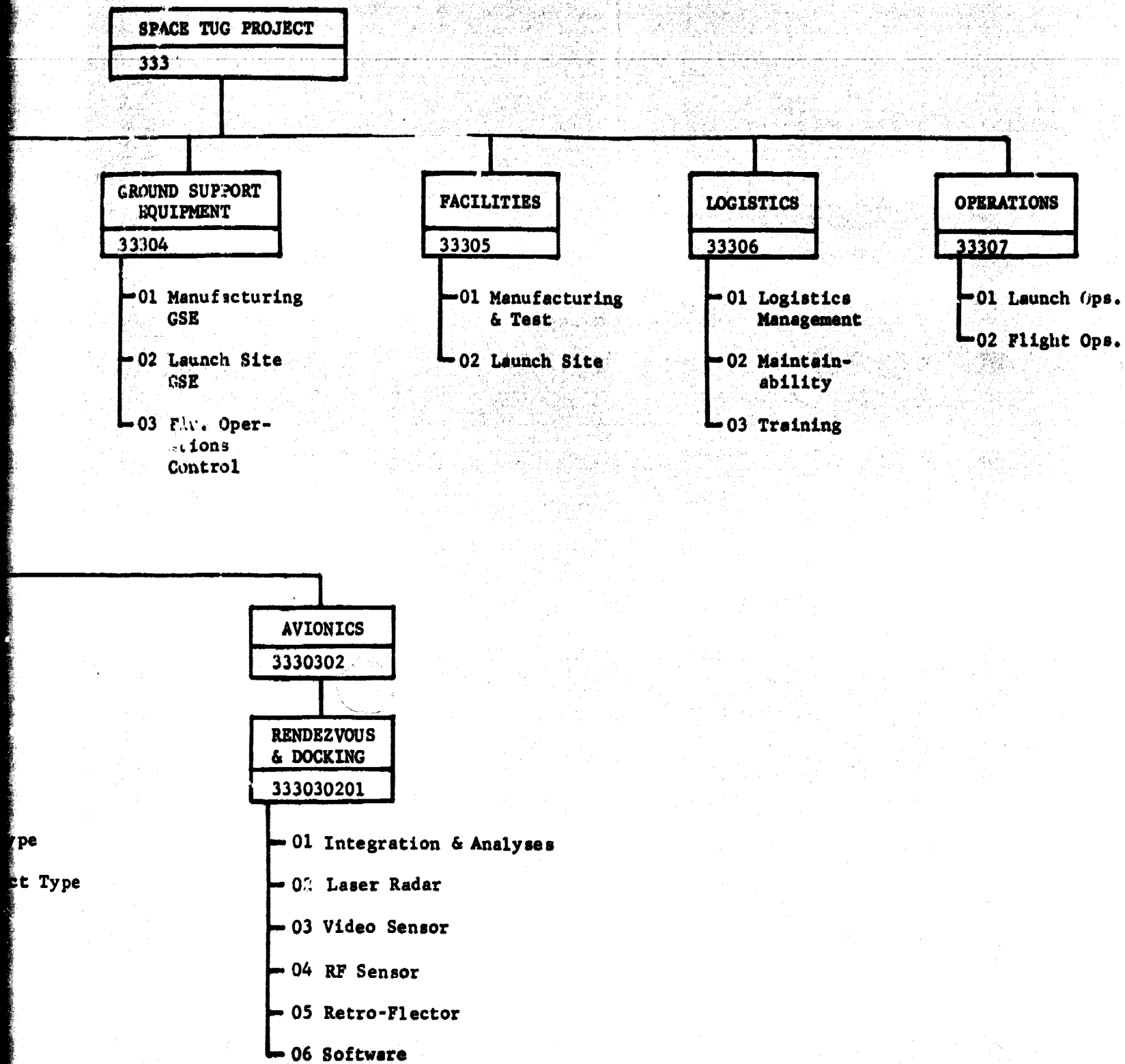


Figure II-1 DDT&E Work Breakdown Structure Diagram

FOLDOUT FRAME

IDENTIFICATION NUMBER				ELEMENT	LEVEL
. ' XX	XX	XX	XX		
3.				Space Tug Project	3
01				Project Management	4
	01			Project Administration & Control	5
	02			Configuration Management	5
	03			Information Management	5
02				Systems Engineering and Integration	4
	01			Systems Engineering	5
	02			Shuttle Interface	5
	03			Payload Interface	5
	04			Reliability and Quality Assurance	5
03				Space Tug Vehicle	4
	01			Structures	5
		01		Docking Mechanism	6
			01	Impact Type	7
			02	Non-Impact Type	7
	02			Avionics	5
		01		Rendezvous and Docking	6
			01	Integration and Analyses	7
			02	Laser Radar	7
			03	Video Sensor	7
			04	RF Sensor	7
			05	Retro-Flector	7
			06	Software	7
04				Ground Support Equipment	4
	01			Manufacturing GSE	5
	02			Launc Site GSE	5
	03			Flight Operations Control	5
05				Facilities	4
	01			Manufacturing and Test	5
	02			Launch Site	5
06				Logistics	4
	01			Logistics Management	5
	02			Maintainability	5
	03			Training	5
07				Operations	4
	01			Launch Operations	5
	02			Flight Operations	5

FIGURE II-2 WBS IDENTIFICATION NUMBER SEQUENCE

333-01-01 PROJECT ADMINISTRATION AND CONTROL

This element is the integrated planning, scheduling, budgeting, statusing, work authorization and cost accumulation of all tasks performed during the Space Tug Project. It includes project performance planning, preparation and maintenance of project schedules, budgets, change control and resource status reports. Also included is continuous monitoring of all functional management disciplines to provide central direction and control, timely resolution of problems and overall surveillance of project progress and goals.

333-01-02 CONFIGURATION MANAGEMENT

This element is all effort to provide an efficient and effective configuration management system which will define, control and account for the hardware and software configurations at any time throughout the period of performance of the project. Included is identification of configuration and interface baselines, control of changes to those baselines, maintenance of a current accountability of the status of those baselines and a progressive verification that the "as-built" configuration agrees with the current configuration baseline or that differences are identified.

333-01-03 INFORMATION MANAGEMENT

This element is the effort required to analyze project documentation requirements and develop, implement, maintain and control a system for the preparation, distribution and maintenance of all internal and deliverable documentation for the Space Tug Project. This includes services to identify, monitor the preparation of, reproduce, distribute and maintain status of documentation, data and information.

333-02 SYSTEMS ENGINEERING AND INTEGRATION

This element summarizes the Space Tug Systems engineering task of directing and controlling a totally integrated engineering effort, including requirements analysis and integration, system definition, system test definition, interfaces, safety, reliability, configuration management, quality engineering, and technology utilization.

333-02-01 SYSTEMS ENGINEERING

This element includes the effort to transform stated requirements for system elements into appropriate functional descriptions. It also includes system definitization, overall system design, design integrity analysis, system optimization, design of test plans, cost/effectiveness analysis, weight and balance analysis, intrasystem and intersystem compatibility analysis and integration of technical and related logistic functions and interfaces to optimize the total system definition and design.

333-02-02 SHUTTLE INTERFACE

This element provides the engineering effort to define and maintain a standard Space Tug interface with the Shuttle, including analysis and identification of Space Tug test and checkout operations affecting that interface; analysis and identification of Space Tug systems configuration changes affecting the interface; evaluation and coordination of recommended changes to the interface; and preparation, submittal, and maintenance of Interface Control Documents.

333-02-03 PAYLOAD INTERFACE

This element includes all engineering effort associated with the Space Tug/Payload interface. Included is system analysis, design, test, and evaluation to ensure the efficient integration of the Space Tug to the various Payloads of the Mission Model, implementation and maintenance of a system to accomplish the Space Tug/Payload integration, and preparation, submittal and maintenance of Interface Control Documents.

333-02-04 RELIABILITY AND QUALITY

This element summarizes technical reliability, quality, and safety tasks necessary to evaluate and assure quality achievement throughout the program. It includes the engineering and management efforts to ensure the Space Tug system hardware elements are designed to meet minimum reliability and quality requirements. It also includes the generation and maintenance of a Reliability Plan and a Quality Program Plan allocating requirements for subsystem design, calculat-

ing mission reliabilities using approved failure rates and recommending areas of improvement, and the conduct of Failure Modes and Effects Analysis and a Single Failure Point Summary in support of the safety analysis and for design improvements. Other tasks include customer liaison, conduct of audits of the in-house and supplier reliability and quality activities, preparation of failure reports, failure analyses and corrective action, and establishment and enforcement of quality standards.

333-03 SPACE TUG VEHICLE

This element summarizes the Space Tug Vehicle subsystems and their assembly and checkout. Tasks for each subsystem include analysis, design, development test, qualification test of components and subsystems, tooling, procurement, hardware fabrication, quality control, and assembly and checkout efforts which satisfy applicable design requirements. Wherever hardware is purchased, this element covers the preparation of specifications, supplier liaison and direction.

333-03-01 STRUCTURES

This element summarizes all work associated with the structures element. Tasks include analysis, design, development, test, materials, manufacturing, quality control tests, qualification test of components and subsystems, and associated support. Additionally, this will include provision of test equipment and tooling for development, qualification and production. Wherever hardware is purchased, this element covers the preparation of specifications, supplier liaison and direction.

333-03-01-01 DOCKING MECHANISM

This element covers the structural/mechanical elements comprising the docking interface between the Tug basic structure and the spacecraft to be delivered/services/retrieved. Tasks include analysis, design, development, test, materials, manufacturing, quality control tests, qualification test of components and subsystems and associated support. Additionally, this will include provision of test equipment and tooling for development, qualification and production. Wherever hardware is purchased, this element covers the preparation of specifications, supplier liaison and direction.

333-03-01-01-01 IMPACT TYPE

The impact type docking mechanisms are those required for the design option where the initial docking contact is made with a planned input velocity in the region of 0.5 to 1.5 ft/sec. These mechanisms include those required to soften docking shock loads, capture the target spacecraft, bring it to a hard docked position and secure it for return to Earth.

333-03-01-01-02 NON-IMPACT TYPE

The non-impact type docking mechanisms are those required for the design option where docking is effected while the Tug is caused to hover in the immediate vicinity of the S/C docking port. Those mechanisms involved include devices required to reach out and grasp the target spacecraft, draw it back to a hard docked position, secure it in this position, and support it for its return to Earth.

333-03-02 AVIONICS

This element summarizes all work associated with the avionics element. Tasks include analysis, design, development, test, materials, manufacturing, quality control tests, qualification test of components and subsystems, and associated support. Additionally, this will include provision of test equipment and tooling for development, qualification and production. Wherever hardware is purchased, this element covers the preparation of specifications, supplier liaison and direction.

333-03-02-01 RENDEZVOUS AND DOCKING

This element consists of hardware and software necessary to provide rendezvous and docking functions. Tasks include analysis, design, development, test, materials, manufacturing, quality control tests, qualification test of components and subsystems, and associated support. Additionally, this will include provision of test equipment and tooling for development, qualification and production. Wherever hardware is purchased, this element covers the preparation of specifications, supplier liaison and direction.

333-03-02-01-01 INTEGRATION AND ANALYSES

This element represents the non-separable effort required to provide the integration and analyses of the rendezvous and docking elements. Typical tasks include: preparation of overall subsystem specifications, schematics and installation drawings; conduct subsystem design studies and analyses; the conduct of subsystem-level development and qualification tests.

333-03-02-01-02 LASER RADAR

This element includes the laser radar sensor used to provide range, range rate and line-of-sight data for computations to accomplish the rendezvous, inspection and docking closure functions. Included is the transmitter, image receiver and associated optics and electronics. Detailed tasks in WBS 333-03-02-01 will be included here whenever the tasks are applicable.

333-03-02-01-03 VIDEO SENSOR

This element includes the television camera(s), electronics and associated optical devices to provide stereo imaging, where applicable, for the determination of range, range rate and LOS data as well as visual observations during the rendezvous, inspection and docking phases. Detailed tasks in WBS 333-03-02-01 will be included here whenever the tasks are applicable.

333-03-02-01-04 RF SUBSYSTEM

This element contains the RF radar transmitter/receiver and associated electronics for determining target range, range rate and LOS data during rendezvous and docking phases. Detailed tasks in WBS 33-03-02-01 will be included here whenever the tasks are applicable.

333-03-02-01-05 RETRO-FLECTOR

This element contains the passive reflecting devices for the video, laser radar or RF radar sensors. These may be optical (mirror, corner reflector) or RF (reflector, frequency doubler, signal delay, phase shift) devices. Detailed tasks in WBS 333-03-02-01 will be included here whenever the tasks are applicable.

333-03-02-01-06 SOFTWARE

This element contains the flight software required to conduct the rendezvous and docking as well as that required to support any sensors that specifically need unique software computations in support of its operation. The software will be incorporated into the Space Tug computer. Tasks include development, coding verification and validation of the software.

333-04 GROUND SUPPORT EQUIPMENT

This element summarizes all ground based equipment required in support of fabrication, launch, flight, recovery and maintenance phases of the Space Tug Project. Items included are hardware, software peculiar to Space Tug ground operations for fabrication and launch, site activation and maintenance. Hardware effort consists of design, fabrication, qualification, documentation and GSE spares.

333-04-01 MANUFACTURING GSE

This element is composed of all ground support equipment required to support the Space Tug manufacturing operations and checkout. Items included are hardware, software, non-deliverable support equipment, maintenance and spares. Hardware effort consists of design, fabrication, qualification and documentation.

333-04-02 LAUNCH SITE GSE

This element includes all ground support equipment required to support launch, recovery and maintenance of Space Tug during operations. Items included are hardware, software and site activation of GSE. Hardware effort consists of design, fabrication, qualification and documentation. All common DDT&E costs will be charged to ETR since it will be the first activated and WTR only charged the development effort peculiar to WTR.

333-04-03 FLIGHT OPERATIONS CONTROL

This element covers ground support equipment in the flight operations control center required to support Space Tug mission operations. Items included are hardware, software and site activation of GSE. Hardware effort consists of design, fabrication, qualification and documentation.

333-05 FACILITIES

This element covers facilities (new or modification to existing) for manufacture, test, maintenance, refurbishment, and launch of an operational Space Tug Vehicle. The basic shuttle launch and operations facilities are not included. However, those launch site facilities built specifically for Space Tug are costed. This effort includes facilities planning, acquisition or modification, and maintenance. Amortization of adequate existing facilities will not be included.

333-05-01 MANUFACTURING AND TEST

This element includes all new and modifications to existing facilities (government and contractor) which are required for the manufacture, test and checkout of subsystems and the complete Space Tug vehicle. It includes planning, A&E services, construction and activation of the facilities.

333-05-02 LAUNCH SITE

This element includes all new or modifications to existing ETR and WTR facilities required for launch, maintenance and refurbishment of the operational Space Tug vehicle. Maintenance and refurbishment facilities include those necessary to accomplish on-site maintenance and repair, modifications, factory repair and refurbishment, and vehicle storage. It includes planning, A&E services, construction and activation of the facilities.

333-06 LOGISTICS

This element summarizes the effort to develop and implement an integrated logistics activity to support the Space Tug Vehicle. It includes maintainability analysis, spares management, analysis of support requirements, inventory management, training requirements and equipment, technical manuals and transportation analyses and planning.

333-06-01 LOGISTICS MANAGEMENT

This element consists of the timely and efficient implementation and management of logistics integration and analysis in support of the Space Tug vehicle. Tasks include the identification of equipment to be maintained; maintenance levels and locations; conducting analysis to determine requirements; development of appropriate logistics plans; development of requirements for propellants and pressurants; determining methods of shipment, shipment scheduling and monitoring, and procurement procedures.

333-06-02 MAINTAINABILITY

This element includes the development of maintainability design criteria and specifications, design analysis and evaluation, and identification of design improvements to facilitate maintenance and maintainability verification. In addition, it includes the generation and maintenance of the Maintainability Plan, identification of equipment to be maintained, maintenance levels and locations, and procedures for handling of maintenance equipment.

333-06-03 TRAINING

This element summarizes all training services, training materials, training aids and training equipment required for factory, technical, flight and ground crew training. It includes instructor services, development and maintenance of study guides, training manuals, and training aids for classroom and trainer instruction.

333-07 OPERATIONS

This element refers to the operations and services required to perform mission planning, launching, and recovery in relation to completing a space mission. This element includes: launch, flight and recovery operations; airborne system assembly and checkout; associated activities directly related to the mission, such as SCF checkout with launch site and verification of home site communications requirements. The effort of providing the operational equipments is excluded. However, flight simulation support is included.

333-07-01 LAUNCH OPERATIONS

This element summarizes all contractor effort and materials to conduct equipment receiving and checkout at the launch site, prelaunch assembly and checkout, transportation of equipment on the test range, logistics support for launch operations, launch support computer programs, propellants, gases, pre/post-flight data reduction and analysis, and the actual countdown and launch operations.

333-07-02 FLIGHT OPERATIONS

This element refers to all contractor effort and material required to perform ground command, control, tracking, and communications with the space vehicle(s). This element includes, for example, mission planning, flight control, telemetry, communications, data processing, data analysis and flight evaluation. Personnel for performing the flight operations functions during development and operational program phases will be costed in these elements, as well as their participation in tests and mission simulations.

2.6 Cost Summary

The DDT&E and first article cost estimates resulting from the cost analysis of the manual, autonomous and hybrid configurations are presented in this section. Summary costs for each configuration are:

	Costs - in $K	
	DDT&E	First Article
Manual	$10,500	$1,480
Autonomous	15,910	1,190
Hybrid	17,200	1,400

Summary fiscal funding requirements for the DDT&E phase of each configuration are:

	Costs - in $K				
	FY77-78	FY79	FY80	FY81	FY82-83
Manual	$1,700	$3,674	$4,292	$616	$218
Autonomous	3,300	3,464	6,533	2,470	143
Hybrid	3,000	3,915	7,361	2,706	218

The total DDT&E (including SRT) and first article costs by major element with a program schedule for manual, autonomous and hybrid configurations are presented in Tables II-1, II-2, and II-3, respectively. These data include an estimate of Phase B definition effort and simulation/demonstration testing as well as the Phase C development and first article build costs estimated in subsequent sections of this report.

Table II-1 Manual Candidate Cost And Schedule

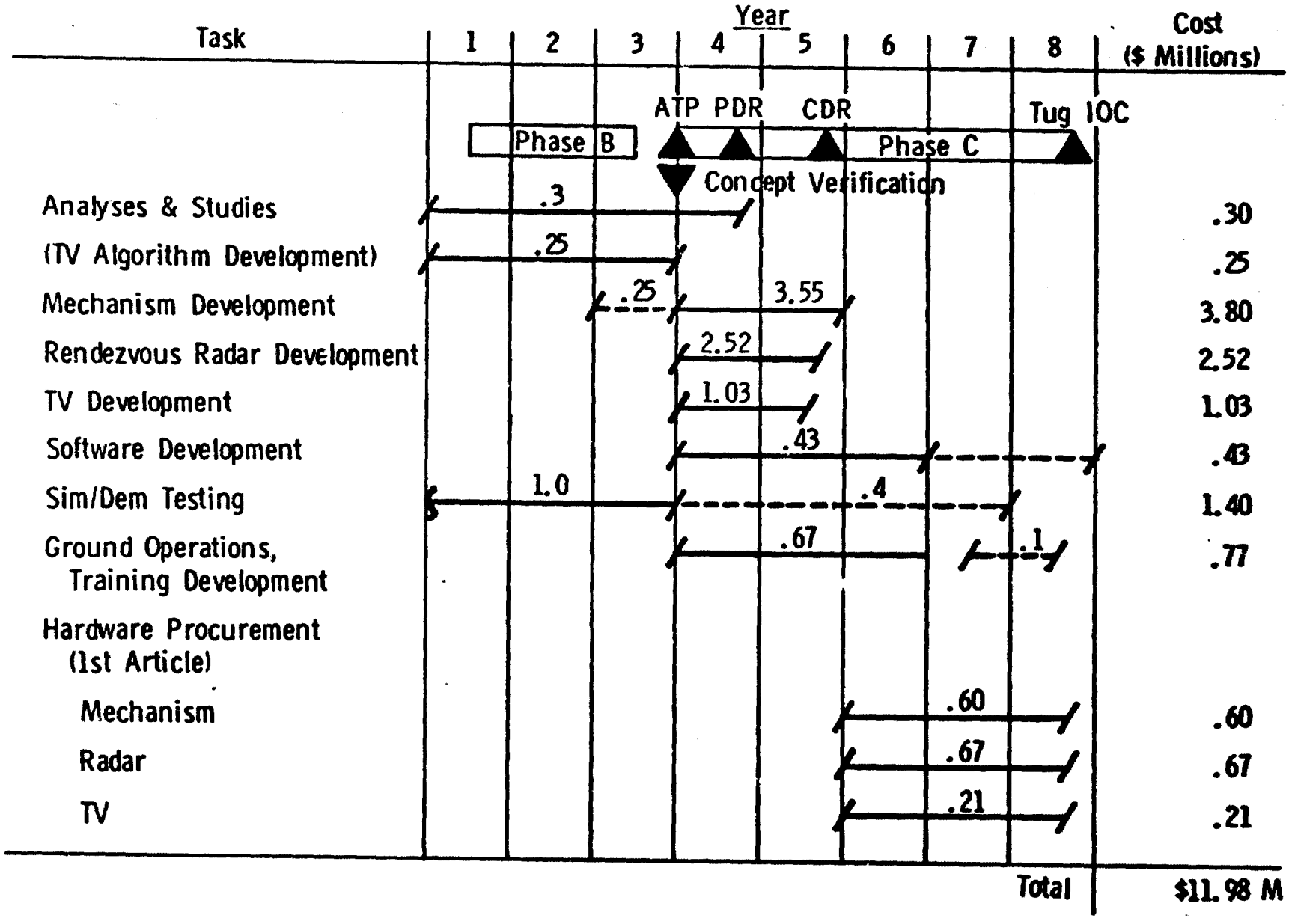


Table II-2 Autonomous Candidate Cost And Schedule

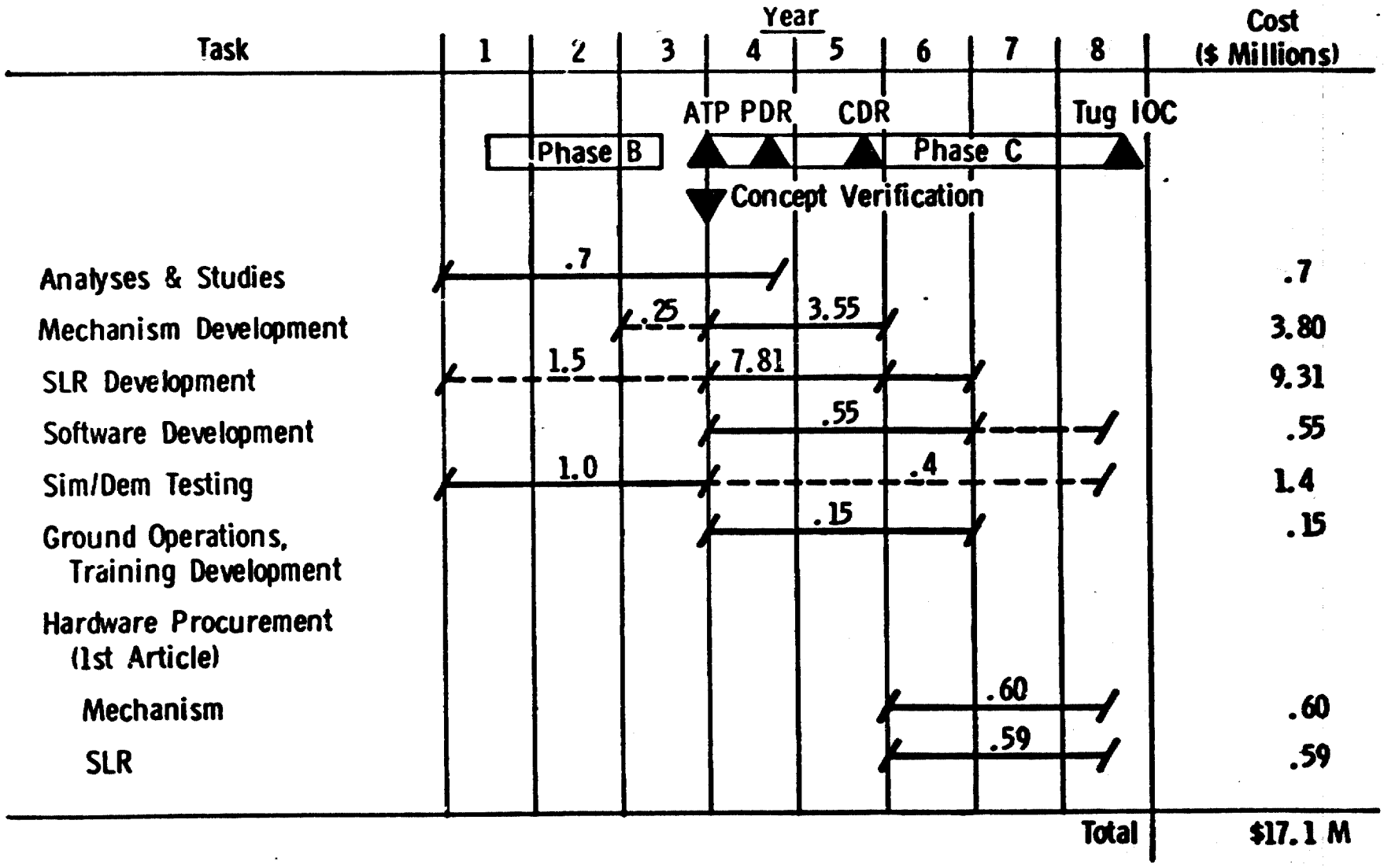
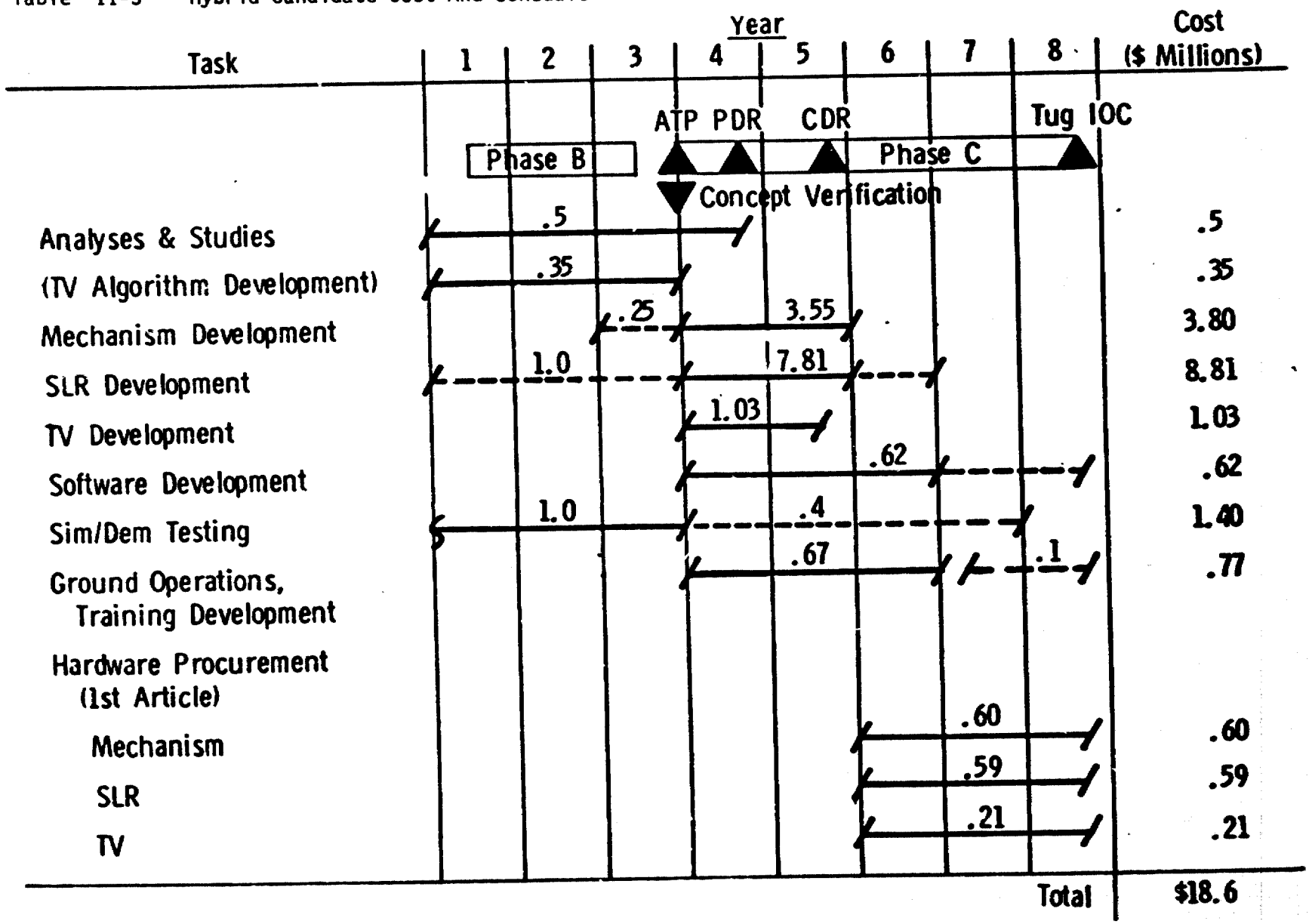


Table II-3 Hybrid Candidate Cost And Schedule



III. COST ESTIMATES BY WBS ELEMENT

3.1 Cost Data Form-A(1)

Non-recurring (DDT&E), is included for the following:

- Task A - Data Base
- Task B - Manual Configuration
- Task B - Autonomous Configuration
- Task B - Hybrid Configuration

3.2 Cost Data Form-A(2)

Recurring (production), is included for the following:

- Task A - Data Base

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COST DATA FORM--A(1)

STUDY TITLE Space Tug Docking Study
CONTRACT NO. NAS8-31542
CONFIGURATION Data Base

NON-RECURRING (DDT&E)
(Dollars in Thousands)

DATE 12/5/75
PAGE 1 OF 2

IDENTIFICATION NUMBER	WBS IDENTIFICATION	WBS LEVEL	EXPECT. COST	CONFID. RATING	T_d	T_s	SPREAD FUNCTION
33 03 01 01 01	Impact Type (MDAC)	7	3,547	2	23	58	
333 03 01 01 01	Impact Type (MMSE)	7	1,500	3	24	58	
333 03 01 01 02	Non-Impact Type	7	7,197	1	36	58	
333 03 02 01 02	Laser Radar (GaAs)	7	7,045	2	36	58	
33 03 02 01 02	Laser Radar (CO_2)(NC)	7	10,800	2	42	58	
33 03 02 01 02	Laser Radar (CO_2)(C)	7	10,600	2	42	58	
333 03 02 01 03	Video Sensor	7	965	2	18	58	
333 03 02 01 04	RF Radar (Non-Coherent)(NC)	7	2,301	2	21	58	
333 03 02 01 04	RF Radar (Non-Coherent)(C)	7	2,150	2	21	58	
333 03 02 01 04	RF Radar (Dual Mode)(NC)	7	7,500	1	30	58	
333 03 02 01 04	RF Radar (Dual Mode)(C)	7	7,300	1	30	58	
333 03 02 01 05	Retro-Flector (Laser)	7	104	2	36	58	

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COST DATA FORM—A(1)

STUDY TITLE Space Tug Docking Study

CONTRACT NO. NAS8-31542

CONFIGURATION Data Base

DATE 12/5/75

PAGE 2 OF 2

NON-RECURRING (DDT&E) (Dollars in Thousands)

IDENTIFICATION NUMBER	WBS IDENTIFICATION	WBS LEVEL	EXPECT. COST	CONFID. RATING	T_d	T_s	SPREAD FUNCTION
333 03 02 01 05	Retro-Flector (RF Micro Strip)	7	380	4	24	58	
333 03 02 01 05	Retro-Flector (RF Trihedral)	7	420	4	24	58	

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COST DATA FORM–A(1)

STUDY TITLE Space Tug Docking Study
CONTRACT NO. NAS8-31542
CONFIGURATION ~~Manual~~

NON-RECURRING (DDT&E)

(Dollars in Thousands)

DATE 12/5/75
PAGE 1 OF 1

IDENTIFICATION NUMBER	WBS IDENTIFICATION	WBS LEVEL	EXPECT. COST	CONFID. RATING	T_d	T_s	SPREAD FUNCTION
333	Space Tug Project	3					
333 03	Space Tug Vehicle	4	(8,203)				
333 03 01	Structures	5					
333 03 01 01	Docking Mechanism	6	(3,547)				
333 03 01 01 01	Impact Type	7	3,547	2	23	58	50/60
333 03 02	Avionics	5					
333 03 02 01	Rendezvous and Docking	6	(3,989)				
333 03 02 01 01	Integration and Analysis	7	293	3	36	58	50/60
333 03 02 01 03	Video Sensor	7	965	2	18	58	50/50
333 03 02 01 04	RF Radar	7	2,301	2	18	58	50/50
333 03 02 01 06	Software	7	430	2	36	58	50/40
333 04	Ground Support Equipment	4	395	2	36	58	50/50
333 06	Logistics	4	136	2	36	58	50/40
333 07	Operations	4	136	2	36	58	50/40

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COST DATA FORM–A(1)

STUDY TITLE Space Tug Docking Study
CONTRACT NO. NAS8-31542
CONFIGURATION Autonomous

NON-RECURRING (DDT&E)

(Dollars in Thousands)

DATE 12/5/75
PAGE 1 OF 1

IDENTIFICATION NUMBER	WBS IDENTIFICATION	WBS LEVEL	EXPECT. COST	CONFID. RATING	T_d	T_s	SPREAD FUNCTION
333	Space Tug Project	3					
333 03	Space Tug Vehicle	4	(12,062)				
333 03 01	Structures	5					
333 03 01 01	Docking Mechanism	6	(3,547)				
333 03 01 01 01	Impact Type	7	3,547	2	23	58	50/60
333 03 02	Avionics	5					
333 03 02 01	Rendezvous and Docking	6	(8,360)				
333 03 02 01 01	Integration and Analysis	7	662	3	36	58	50/60
333 03 02 01 02	Laser Radar	7	7,045	2	36	58	50/60
333 03 02 01 05	Retro-Flector	7	104	2	36	58	50/60
333 03 02 01 06	Software	7	549	2	36	58	50/40
333 04	Ground Support Equipment	4	11	2	36	58	50/50
333 07	Operations	4	144	2	36	58	50/40

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COST DATA FORM–A(1)

STUDY TITLE Space Tug Docking Study
CONTRACT NO. NAS8-31542
CONFIGURATION Hybrid

NON-RECURRING (DDT&E)

(Dollars in Thousands)

DATE 12/5/75
PAGE 1 OF 1

IDENTIFICATION NUMBER	WBS IDENTIFICATION	WBS LEVEL	EXPECT. COST	CONFID. RATING	T_d	T_s	SPREAD FUNCTION
333	Space Tug Project	3					
333 03	Space Tug Vehicle	4	(13,682)				
333 03 01	Structures	5					
333 03 01 01	Docking Mechanism	6	(3,547)				
333 03 01 01 01	Impact Type	7	3,547	2	23	58	50/60
333 03 02	Avionics	5					
333 03 02 01	Rendezvous and Docking	6	(9,468)				
333 03 02 01 01	Integration and Analyses	7	738	3	36	58	50/60
333 03 02 01 02	Laser Radar	7	7,045	2	36	58	50/60
333 03 02 01 03	Video Sensor	7	965	2	18	58	50/50
333 03 02 01 05	Retro-Flector	7	104	2	36	58	50/60
333 03 02 01 06	Software	7	616	2	36	58	50/40
333 04	Ground Support Equipment	4	395	2	36	58	50/50
333 06	Logistics	4	136	2	36	58	50/40
333 07	Operations	4	136	2	36	58	50/40

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COST DATA FORM–A(2)

STUDY TITLE Space Tug Docking Study
CONTRACT NO. NAS8-31542
CONFIGURATION Data Base

DATE: 12/5/75
PAGE 1 OF 2

RECURRING (PRODUCTION)

(Dollars in Thousands)

IDENTIFICATION NUMBER	WBS IDENTIFICATION	WBS LEVEL	NO. OF UNITS		EXPECTED COST	REF. UNIT	REF. UNIT COST	CONFIG. RATING	T_d	T_s	SPREAD FUNCTION	LEARN INDEX
333 03 01 01 01	Impact Type (MDAC)	7				1	602	2	28			
333 03 01 01 01	Impact Type (MMSE)	7				1	761	2	12			
333 03 01 01 02	Non-Impact Type	7				1	802	1	30			
333 03 02 01 02	Laser Radar (GaAs)	7				1	583	2	24			
333 03 02 01 02	Laser Radar (CO_2)(NC)	7				1	1,258	2	30			
333 03 02 01 02	Laser Radar (CO_2)(C)	7				1	1,167	2	30			
333 03 02 01 03	Video Sensor	7				1	204	2	24			
333 03 02 01 04	RF Radar											
	Non-Coherent(NC)	7				1	670	2	24			
333 03 02 01 04	RF Radar											
	Non-Coherent(C)	7				1	622	2	24			

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COST DATA FORM–A(2)

STUDY TITLE Space Tug Docking Study
CONTRACT NO. NAS8-31542
CONFIGURATION Data Base

RECURRING (PRODUCTION)

(Dollars in Thousands)

DATE: 12/5/75
PAGE 2 OF 2

IDENTIFICATION NUMBER	WBS IDENTIFICATION	WBS LEVEL	NO. OF UNITS		EXPECTED COST	REF. UNIT	REF. UNIT COST	CONFIG. RATING	T_d	T_s	SPREAD FUNCTION	LEARN INDEX
333 03 02 01 04	RF Radar											
	Dual Mode (NC)	7				1	804	2	24			
333 03 02 01 04	RF Radar											
	Dual Mode (C)	7				1	756	2	24			
333 03 02 01 05	Retro-Flector											
	(Laser)	7				1	21	2	24			
333 03 02 01 05	Retro-Flector											
	(RF Micro Strip)	7				1	29	4	24			
333 03 02 01 05	Retro-Flector											
	(RF Trihedral)	7				1	34	4	24			

IV. TECHNICAL CHARACTERISTICS DATA

The technical data for components comprising the Task A data base is presented on Technical Characteristics Data Form B. The lists include major sizing and performance characteristics which define the selected components.

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TECHNICAL CHARACTERISTICS DATA FORM B

STUDY TITLE LST-
CONTRACT NO. NAS8-31312
CONFIGURATION

DATE
PAGE OF

WBS IDENTIFICATION NUMBER	WBS IDENTIFICATION	QUANTITY OR VALUE	UNITS OF MEASURE	CHARACTERISTICS	NOTES
333 03 01	Structures				
333 03 01 01	Docking Mechanism				
333 03 01 01 01	Impact Type			McDonnell Douglas Docking Mechanism	
		252 (556)	Kg (lb)	Weight	
	Impact Type			MMSE	
		440 (970)	Kg (lb)	Weight	
333 03 01 01 02	Non-Impact Type			Non Impact (New Design)	
		241 (531)	Kg (lb)	Weight	
333 03 02	Avionics				
333 03 02 01	Rendezvous & Docking				
333 03 02 01 01	Laser Radar				
	GaAs Scanning Radar			Pulsed Laser Radar (Cooperative)	
		.04 (1.4)	m^3 (ft^3)	Volume	
		25 (55)	Kg (lb)	Weight	
		40	Watts	Power	

STUDY TITLE LST-
CONTRACT NO. NAS8-31312
CONFIGURATION

DATE
PAGE ___ OF ___

WBS IDENTIFICATION NUMBER	WBS IDENTIFICATION	QUANTITY OR VALUE	UNITS OF MEASURE	CHARACTERISTICS	NOTES
	CO_2 Laser Radar			(Non-Cooperative)	
		22.6 (50)	Kg (lb)	Weight	
		200	Watts	Power	
	CO_2 Laser Radar			(Cooperative)	
		18 (40)	Kg (lb)	Weight	
		100	Watts	Power	
333 03 02 01 02	Video Sensor				
	TV Camera and Electronics				
		9 (20)	Kg (lb)	Weight	
		12	Watts	Power	
333 03 02 01 03	RF Radar				
	Non-Coherent Pulse Doppler			Non-Cooperative	
		34 (75)	Kg (lb)	Weight	
		275	Watts	Power	
	Non-Coherent Pulse Doppler			Same as above only cooperative.	
		31.7 (70)	Kg (lb)	Weight	
		120	Watts	Power	

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TECHNICAL CHARACTERISTICS DATA FORM B

STUDY TITLE LST-
CONTRACT NO. NAS8-31312
CONFIGURATION

DATE
PAGE OF

WBS IDENTIFICATION NUMBER	WBS IDENTIFICATION	QUANTITY OR VALUE	UNITS OF MEASURE	CHARACTERISTICS	NOTES
333 03 02 01 03	RF Radar (cont)				
	Dual Mode Pulse Doppler			Radar above combined with X-band, coherent pulse doppler short range radar non-cooperative.	
		36.3 (80)	Kg (lb)	Weight	
		275	Watts	Power	
	Dual Mode Pulse Doppler			Same as above only cooperative rendezvous radar.	
		34 (75)	Kg (lb)	Weight	
		120	Watts	Power	
333 03 02 01 04	Retro-Flector			Laser Optical	
	Laser Reflector (2) required			Corner reflector-solid glass (35C-2)	
		6.35 (2.5)	cm (in)	Diameter	
		.23 (.5)	Kg (lb)	Weight	
	RF Radar Antenna (4) Required			RF printed microstrip reflecting antenna	
		5 x 5 x 1.27 (2 x 2 x .5)	cm (inches)	Size	
		.17 (.375)	Kg (lb)	Weight	

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TECHNICAL CHARACTERISTICS DATA FORM B

STUDY TITLE LST-
CONTRACT NO. NAS8-31312
CONFIGURATION

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WBS IDENTIFICATION NUMBER	WBS IDENTIFICATION	QUANTITY OR VALUE	UNITS OF MEASURE	CHARACTERISTICS	NOTES
	RF Radar Cooperative Ranging Antenna			Trihedral, triangular corner reflector.	
		.24 x .24 x .24 m (.8 x .8 x .8	(ft)	Size	
		.9 (2)	Kg (lb)	Weight	

V. TOTAL PROGRAM FUNDING SCHEDULES

Fiscal year funding estimates for each of the Task B configurations are presented in Funding Schedule Data Form C. Lower level WBS elements were time-phased by fiscal year using the appropriate spread function selected from Figure 8 of NASA DRD MF003M and summed to the higher level.

FUNDING SCHEDULE DATA FORM C

STUDY TITLE: Space Tug Docking Study
CONTRACT NO.: NAS8-31542
CONFIGURATION: Manual

Non-Recurring (DDT&E)
Date: 12/5/75
Page 1 of 3

(Dollars in Thousands)

PROJECT WBS ITEMS	FY 79	FY 80	FY 81	FY 82	FY___	FY___	FY___
333 03 01	1,694	1,853					
333 03 02	1,719	1,994	264	12			
333 04	41	217	135	2			
333 06	10	64	59	3			
333 07	10	64	59	3			
Total - DDT&E	3,474	4,192	517	20			

FUNDING SCHEDULE DATA FORM C

STUDY TITLE: Space Tug Docking Study
CONTRACT NO.: NAS8-31542
CONFIGURATION: Autonomous

Non-Recurring (DDT&E)
Date: 12/5/75
Page 2 of 3

(Dollars in Thousands)

PROJECT WBS ITEMS	FY 79	FY 80	FY 81	FY 82	FY___	FY___	FY___
333 03 01	1,694	1,853					
333 03 02	1,508	4,507	2,303	42			
333 04	1	6	4				
333 07	11	67	63	3			
TOTAL - DDT&E	3,214	6,433	2,370	45			

FUNDING SCHEDULE DATA FORM C

STUDY TITLE: Space Tug Docking Study
CONTRACT NO.: NAS8-31542
CONFIGURATION: Hybrid

Non-Recurring (DDT&E)
Date: 12/5/75
Page 3 of 3

(Dollars in Thousands)

PROJECT WBS ITEMS	FY 79	FY 80	FY 81	FY 82	FY___	FY___	FY___
333 03 01	1,694	1,853					
333 03 02	2,010	5,063	2,352	43			
333 04	41	217	135	2			
333 06	10	64	59	3			
333 07	10	64	59	3			
TOTAL DDT&E	3,765	7,261	2,605	51			